USING COMMUNICATION RELATED INFORMATION TECHNOLOGIES:

POTENTIAL INFLUENCE AND IMPLEMENTATION ISSUES

Oscar Hauptman, Kenneth E. Bodenham, Thomas J. Allen

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ABSTRACT

The objective of the article is to identify for the managers of technology-based organizations the main issues they typically have to face in considering the introduction of new communication related information technologies, and in implementing them. It might prove especially useful for vendors of these technologies, in consulting their customers about the optimal choice and utilization of their products.

The first part of the article is mostly conceptual and it consists of three sections: first, a brief review of previous research in the area of communication in R&D, its determinants, and its influence on project team productivity. Second, a review of previous research of information technologies, and their potential influence on individual behavior in organizations. Finally, we present a conceptual model of the potential influence of information technologies on communication in technology based organizations, which could serve as a guideline for structural decisions in such organizations.

The second part of the article is based on empirical data collected at ICL Applied Systems in two main areas: first, the study of communication patterns of software professionals, and the relationships between these communication patterns and software project team performance. The last part is a chronological review of the PABX SHOWCASE experience at ICL, supported by a peliminary empirical data on use of information systems.

PART I: PREVIOUS RESEARCH AND CONCEPTUAL FRAMEWORK

INTRODUCTION: COMMUNICATION AND PERFORMANCE OF R&D PROJECT TEAMS

Communication in organizations is probably one of the most central and challenging managerial issues. Barnard's statement outlines the role of communication as follows (1938: 82):

> An organization comes into being when there are persons (1) able to communicate with each other, (2) who are willing to contribute action, (3) to accomplish a common purpose. . . . the elements for an organization therefore are (1) communication, (2) willingness to serve, and (3) common purpose. The elements are necessary and sufficient conditions initially and they are found in all organizations.

The perceived importance of communication has increased since then, and organizational communication became a much more practical, applied issue. If Barnard wrote for organizational theorists, Sanford, Hunt, & Bracey (1976: 9-10) describe the role of communication for students of management, mostly MBAs, entering the real world of industrial management:

> An organization is a social system of structured individual roles and tasks which require coordination and communication to accomplish a specific purpose. . . . Communication is the vehicle through which coordination is accomplished . . . Coordination and communication are so similar in effect that it is difficult to conceive one without the other. The transfer of information within the organization enables the system to transform raw materials into outputs.

The determinants of technical communication patterns of R&D project teams have been studied at MIT by Allen and colleagues[1]. On the basis of these and other studies[2] it became obvious that the frequency with which information sources are used is determined by their accessibility, their perceived technical quality, and the past experience with the source of information[3] . The selection of information sources is influenced more by accessibility and past experience with the source, than by their technical quality. As a

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[1]For intance Allen (1970); Allen & Fusfeld (1975); Allen, Lee, & Tushman (1980); Katz & Allen (1982).
[2]Summarized by Epton (1981).
[3]Allen (1977).

result of this selection logic, perceived low accessibility of libraries and information databases, or of physically removed individuals, may render them underutilized, in spite with their perceived high technical quality. At the same time the physically proximal, and consequently the accessible sources, be it individuals or publications, may be overused in spite with their possible technical deficiencies such as obsolescence or a narrow focus.

Allen[1] documented the influence of several factors on the frequency of communication among technical professionals. First, the physical distance between the communication partners is a strong determinant of the probability that communication will occur. Second, the organizational bonds between the communication partners will increase this probability, controlling for physical proximity. Third, the architectural attributes of the R&D environment, such as office arrangements, vertical separation, and the nuisance factor can direct and structure communication[2].

In the domain of research and development tasks, numerous research findings[3] show that patterns of communication among technical professionals in R&D laboratories are significant determinant of the technical performance and productivity of project teams. A recent study carried out at ICL Applied Systems Division by Hauptman[4] corroborates these findings in the specific domain of software development and production.

But one cannot discuss organizational communication these days without at least speculating about the impact the explosive development in information technologies will have on such communication.

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[1]Allen (1970, 1977).
[2]See also Tomlin (1979).
[3]E.g., Shilling & Bernard (1964); Marquis & Allen (1966); Pelz & Andrews (1966); Allen (1977).
[4]Hauptman (1986a, 1986b).

POTENTIAL INFLUENCE OF INFORMATION TECHNOLOGIES ON ORGANIZATIONAL COMMUNICATION

The Promise of Information Technologies

The following rational-economic assessment of digital communication is probably typical of the enthusiastic perception of the promise of new communication related information technologies:

> The phone also shares a problem with all speech communication: the information density of speech is very low. Generally, the electronic transmission of speech requires about 60,000 bit per second. These 60,000 bits of speech carry about the same information as 15 characters of written text... But you can transmit 15 characters directly as text by transmitting only 120 bits of information, rather than 60,000 bits of speech. . . . In a very fundamental sense, speech is not an economic medium of communication (Marill, 1980: 185).

It might seem that the new text media technologies, such as electronic mail or computer-mediated conferencing, offer numerous advantages vis-a-vis oral communication. Picot, Klingenberg, & Kranzle (1982) list such advantages as effective decentralization of autonomous work groups, including work at home. Hiltz & Turoff (1978: 8-9) in their detailed case study of a computer-conferencing package (EIEC) suggest that:

> 1. Time and distance barriers are removed. Participants can send and receive communications whenever it is convenient for them, with the material . . . to be received or revised . . . again and again . . .
> 2. Group size can be expanded without decreasing actual participation by either member. . . . No one can be interrupted or 'shouted down'. In addition, since it is possible to read much faster than listen, much more total infromation can be exchanged in a given amount of time.
> 3. A person participates at a time and rate of his or her own choice. You need not leap out of the bathroom to answer a ringing telephone, or drag yourself out of a hotel bed at 7a.m. to make a meeting that begins at 9a.m.

This positive outlook is shared by some practitioners, e.g., Roger Smith, Chairman of General Motors who refers (1985: 5) to information-communication technologies as the vehicle for what he calls the "21st Century Corporation". According to Smith it entails:

> . . . an integrated, coordinated, decision-making way of functioning which comprehends business plans, budgets, product programs, corporate volumes, and everything else that helps run the business. it must create an integrated worldwide data base that brings all parts of the busines together.

If Hiltz & Turoff (1978) see the main application of information technologies in replacing and complementing face-to-face and telephone interactions, Smith (1985: 6) prediction is focusing on the replacement of paper-based information and communication:

> Just as automobiles of today are increasingly moving from mechanical controls to elctronic controls, so must the businesses of today switch from paper to an electronic flow of data.

This enthusiasm with a new set of management relevant technologies is still wanting of rigorous, empirical evidence in real-life industrial and governmental settings. Nevertheless several important findings should be mentioned. Hiltz & Turoff (1978) provide detailed protocols of interactions via a computer-conferencing package, and suggest that it could possibly replace other media of communication, such as face-to-face, telephone and mail. It also seems that the electronic text medium is inherently disciplined because of the cognitive nature of communication imposed by the written medium; it should presumably filter the affective components of human interaction[1].

The asynchronous nature of computer-mediated interactions also makes interactions more egalitarian. They are less influenced by status, or the verbal eloquence or aggressiveness of the individual. Both Hiltz and Turoff (1978), and Siegel et al. (1984)[2] showed that participation in discussions is more equally distributed among participants than what could be expected from similar face-to-face groups.

These studies also provide some reference to the efficiency and effectiveness of communication. For instance Siegel et al. (1984) found that it usually took the computer-mediated groups longer to reach a solution. Possibly the fact that these groups exchanged fewer remarks than face-to-face groups impaired the flow of task-relevant information. It should be mentioned, though, that the computer-mediated groups were as task-oriented, and more quantitative than face-to-face groups.

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[1]See for instance Johansen, Vallee, & Collins (1977).
[2]Conducted at the Social Science Research of Computing Center at the Carnegie-Mellon University.

These findings are indicative of the potential limitations imposed by the medium. Obviously, the efficiency of transmitting digital data via the computer, described by Marill (1980), narrows the band in the same ratio, in this case by 500 (60,000 to 120). The 60,000 bits of speech are transmitting not only 15 characters of verbal data but also vocalization - pauses, pitches and tones.

Even the traditional voice medium, the telephone, is incomparably more narrow-banded than face-to-face interactions. It totally lacks the visual channel, which includes the physical attributes of the person, such as age, and sex. This screening can be regarded as positive because it could prevent potential biased responses, based on individual's task unrelated attributes. Obviously, the medium screens out facial expressions, eye contacts, body movements, and psycho- physiological responses, but the importance of these cues remains questionable.

The central questions of what are the realistic benefits that can be derived from communication relevant information technologies to organizations, remain unanswered. To what extent these technologies have the potential to express themselves at the "bottom line", and in what ways. There are organizational tasks which are more amenable to productivity increase through information technologies than other tasks, which might look quite similar. It is clear that the exploitations of these technologies has to be administered with insight about communication related issues and constructs, and with tremendous organizational astuteness.

What implication the reviewed studies have for industrial management are not always clear or obvious. Because our objective is to provide usable concepts and ideas for the managers of technology based organizations, our next step is to specify the expected impact of new information technologies on their communication and structure.

The Influence of Structure on Communication in R&D

The achievement of effective communication has been very high among

the priorities of R&D managers. Typically the various types of communication have been enhanced through a mixture of organizational structure and architectural design. It is important to realize that technology based organizational have to face two conflicting goals[1]:

1. The activities of the various disciplines and specialties must be coordinated in order to accomplish the work of multi-disciplinary projects.

2. Projects must be provided with state-of-the-art information in the technologies they draw upon.

There is a trade-off between these two goals that spawned the various organizational forms and structures used in technology based organizations. When the organization is built around specific disciplines or technical specialties, namely, being a "functional" organization, it will most effectively accomplish the second goal of maintaining current technological know-how. On the other hand, when R&D professionals are grouped into projects working towards a common output goal, this structure will accomplish effective coordination of their activities. The matrix type of organizational structure is another attempt to resolve the goal trade-off by integrating the two pure structures described above.

But what concepts could guide management in deciding which way they should go, "functional", "project", or even "matrix"[2]? The informational requirements of the task are obviously central in this decision making. Before we review the potential impact of communication technologies on work-related communication in general, it would be useful to describe the types of communication common to technology based organizations. There are typically two main manageable types of communication between which a balance should be reached to achieve optimal organizational performance. The first type is similar to work-related communication in any type of organization. It is the communication which brings together the various outputs of technical work

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[1]Allen (1985).
[2]For details about matrix related issues see Katz & Allen (1985).

towards a common, integral goal - completion of a product or an R&D project. It transmits the results of one engineer's work to colleagues whose work depends on those results. This communication is clearly coordinative, and it is not unique to R&D laboratories. It exists in any type of organization.

However, there is an additional type of communication which plays a crucial role in determining the success and failure of R&D endeavors. This type of communication is a vehicle of know-how and technology transfer, which keeps the technical professional informed about the recent developments in their technical specialties. In the short run their task may not necessarily require it, but in the long run this type of communication can have a very significant effect on the quality of their work.

The following conceptual model provides general guidelines for organizational design decision making. It is based on the informational needs of typical R&D tasks, and how the two main alternatives of project and functional structures help to accomplish them. The model defines the Organizational Structure Space and is based on the following premises: first, technologies vary in their <u>rate</u> of development, and in the advancement of their frontier; some technologies are more mature and stable, other more dynamic. The rate of change of technological know-how, defined as the first derivative of knowledge by time, dK/dt, can serve as a coordinate of Organizational Structure Space; the higher is the dK/dt, the stronger is the need of the task for <u>effective</u> transfer of state-of-the-art technology. Consequently, the more effective becomes the specialty oriented functional structure in accomplishing this.

The second dimension of the Organizational Structure Space is related to the same need for acquisition of technical information -- the duration of an individual's assignment to a task. If the assignment (T_i) is comparatively short, a technical professional working even in a rapidly advancing technology is unlikely to lose touch with its state-of-the--art. On the other hand, in a long assignment of a year or more, being isolated from peers in the specialty or discipline will carry the dangers of professional obsolescence.

Figure 1: Organizational Structure Space (modified from Allen, 1985, Figure 5)

Legend:

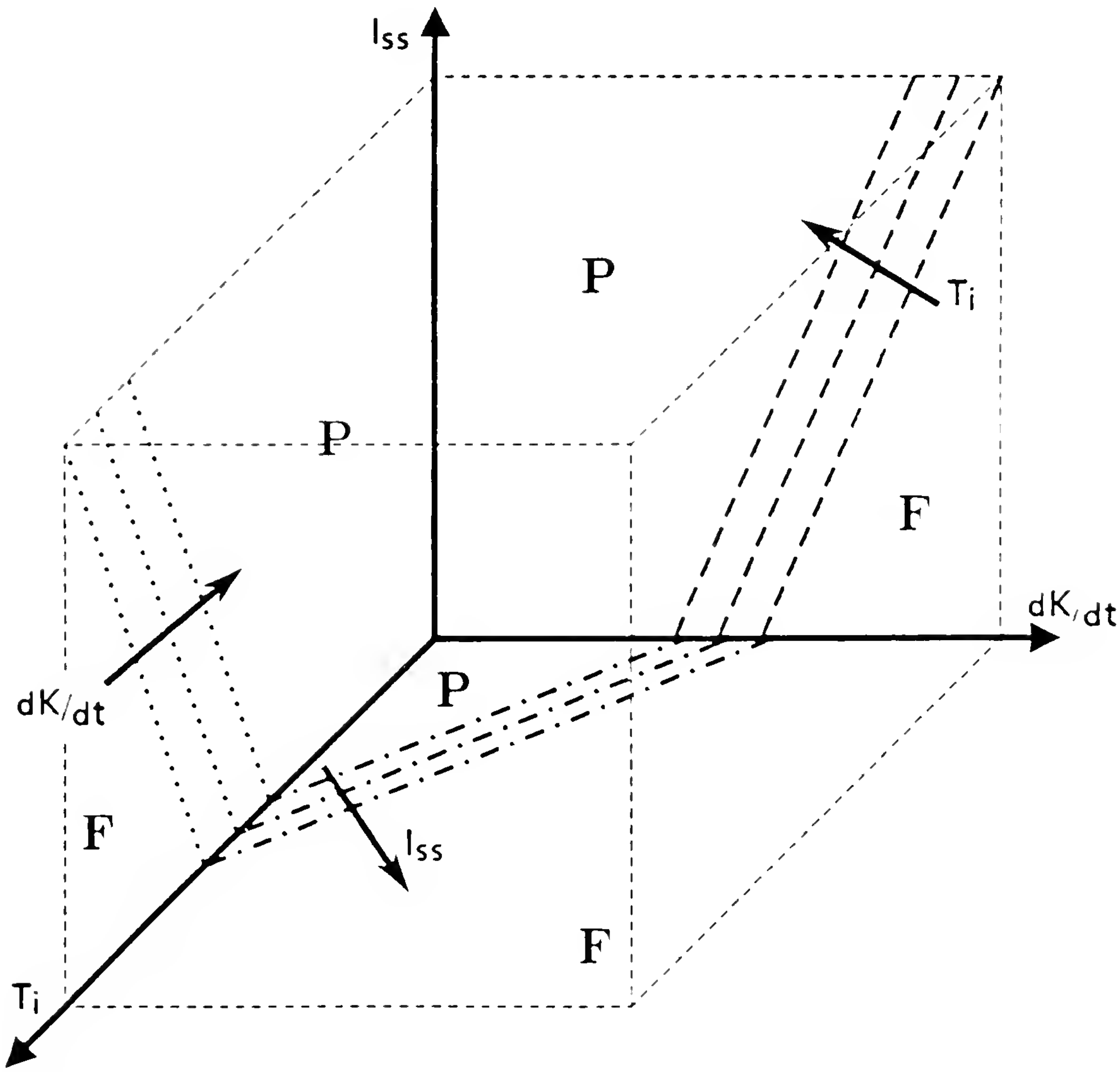
dK/dt - *Rate of change of knowledge*

T_i - *Task duration*

I_{ss} - *Task interdependence*

F - *Functional structure recommended*

P - *Project structure recommended*



The third dimension of the decision space is related to the requirement for organizational coordination, of bringing together the expertise of different professionals towards a single output goal. It is the interdependence among sub-systems and components which comprise the task. The higher is this interdependence (I_{ss}) and the co-influence of these sub-tasks in the joint output, the stronger is the demand from the task team for coordination of its activities.

The resulting Organizational Structure Space effectively combines its main three determinants (Figure 1). The prescriptions emerging from this graphical representation are simple conceptually, although the quantitative assessment of the three variables for an R&D laboratory, or a technology based organization could prove to be quite elusive. Qualitatively though the prescriptions to management of an R&D laboratory are:

1. For rapidly advancing technologies, <u>ceteris paribus</u>, prefer functional structures to project teams;
2. If the scale of the task is such that the assigned personnel will be expected to spend a long period of time on the task, <u>ceteris paribus</u>, prefer functional structures;
3 Finally, if the sub-tasks of the joint task seem to be highly interdependent, co-influencing each other in an intricate way, <u>ceteris paribus</u>, prefer the project structure, which will accomplish effective coordination of these sub-tasks.

After postulating these general rules for organizational structure, which most effectively facilitate relevant communication by the task team, the question is -- what could be the influence of information technologies, such as electronic mail or database retrieval technologies on this model. Rephrasing this, in what way the prescribed division of the Organizational Structure Space into "Function" and "Project" might be altered under the influence of new information technologies.

<u>The Potential of Information Technologies for Coordination and Technology Transfer</u>

Although, as we emphasized before, there is still insufficient data

for a meaningful answer whether or not communication related information technologies are powerful enough to change individual and organizational behavior, we can hypothesize that some of the functions which are assigned to organizational structure might be assumed by these technologies.

As the first hypothesis one could argue that improvements in information technologies will make it easier for technical professionals to maintain up-to-date technological know-how. Through direct access of technological and scientific databases, which by the end of 1984 numbered 2800[1], selective dissemination systems, incorporating artificial intelligence techniques[2], the technical professional will find it easier to use literature, to keep in touch with the discipline or specialty. The exploitation of these information technologies will make the project structure effective for a new set of tasks of rapidly changing technologies by improving the coupling of technical professionals with relevant information sources. As a corollary, if at the present this information has been disseminated in the technology based organization through internal informal consulting with colleagues, usually "gatekeepers"[3], the new technologies might make this informal role obsolete, or at least not as important as at the present.

The second possible impact is that some information technologies might prove effective in fulfilling the coordinative need of a task team. A local example in ICL is the EXAC, a mainframe-based project management system incorporating electronic mail facilities and techniques. This type of information system will attain a goal previously accomplished by the "Project" structure, obviating the need for direct, face-to-face, synchronous contact among project team members, or between team members, and interdependent others in the organization. Consequently, functional structures might become feasible and effective for a new set of highly interdependent technical tasks.

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[1]Cuadra Associates (1984).
[2]For instance Malone (1986).
[3]Allen & Cohen (1969).

The research in the area of information technologies reviewed above suggests that the latter, coordination oriented utilization of these technologies will dominate. The basis for this contention is the relationship between the type of task and the information needs of the members of teams who perform them. From previous research of R&D tasks[1] it became clear that for more structured, routinized task of low uncertainty and variety there is greater value to the coordinative dimension of communication. Allen, et al.[2] in their conclusions emphasize that while development projects benefited from communication with the rest of the R&D laboratory and the rest of the firm, especially marketing and production, research and technical service projects did not follow this pattern. In addition, only the technical service projects consistenly benefited from management controlled communication with the environment external to the project team. Consequently, the potential benefits of electronic communication media for coordination seem more probable; for instance (Allen, 1985):

> . . . information about project or sub-system status, progress on particular technical problems, changes in product configuration and so on can be easily communicated by information systems and readily understood by engineers engaged in a project. In this sense, information technology, by providing improved means for updating and transmission of this information should have a significant impact. At present, most projects are coordinated, as they have been for years, by means of periodic review meetings and written status reports or memoranda. There is absolutely no reason why such devices cannot be put 'on-line'.

On the other hand, the logic of the two-stage process of information acquisition by technical professionals in organizations[3] is discouraging for potential benefits from information technologies. The role of the technological "gatekeeper" is not only to acquire and disseminate difficult to access and use information, but also to translate this arcane scientific information, predominantly from publications, to concepts and terms which are more usable for technical professionals[4]. Consequently, even when the most current literature

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[1]Allen, Lee, & Tushman (1980); Hauptman (1986a, 1986b).
[2]Allen, Lee, & Tsuhman (1980: 18).
[3]Allen (1977: 149).
[4]For instance Allen & Cohen (1969); Taylor (1975); Tushman (1977); Tushman & Scanlan (1981).

could be accessed close to the time of its "production" via database retrieval information technologies, the principal means for communicating knowledge and technology will remain the face-to-face contact with organizational colleagues. It is still difficult to envisage such technologies which will be efficient in overcoming the need for keeping abreast with the technological edge.

Data collected via questionnaire surveys in ICL Applied Systems are informative in this context. When the participants of the survey were asked which are the most extensively used communication channels for the transmission of comparatively complex information, their answers indicated that face-to-face contacts significantly outweigh other means of communication such as telephone or mail (see Appendices A1-A2 for details). We believe that these behavior can be extrapolated to other technologies such as electronic mail[1].

These ideas gain some support in a more general, non-R&D context. For intance Rice (1980) hypothesized that computer-mediated interactions are adequate only for some of the organizational tasks, namely, for exchanging information and opinions, queries, and generating ideas. The list of activities which according to Rice should not yield to "technological treatment" because of their complexity, and their demand for higher interpersonal involvement included bargaining, resolution of disagreement, getting to know someone, and generally tasks requiring constant focused discussions. In the same vein, the main benefit of the communication related information technologies will be for effective coordination of technical tasks rather than for know-how transfer, which can be described as a complex task requiring more intense social interaction and involvement[2]. Similarly, transmission of numeric data such as budgets and schedules is more easily accomplished by data oriented media such as electronic mail and computer conferencing[3].

On the basis of this argument the hypothesized effect of information

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[1]Picot, Klingenberg, & Krantzle (1982) data are quite similar; see Appendices B1-B3 for details.
[2]See for instance Short et al. (1976); Rice & Case (1981).
[3]Daft & Macintosh (1981).

Figure 2: Influence of Communication Related Information Technologies on the Organizational Structure Space

Legend:

dK/dt - *Rate of change of knowledge*

T_i - *Task duration*

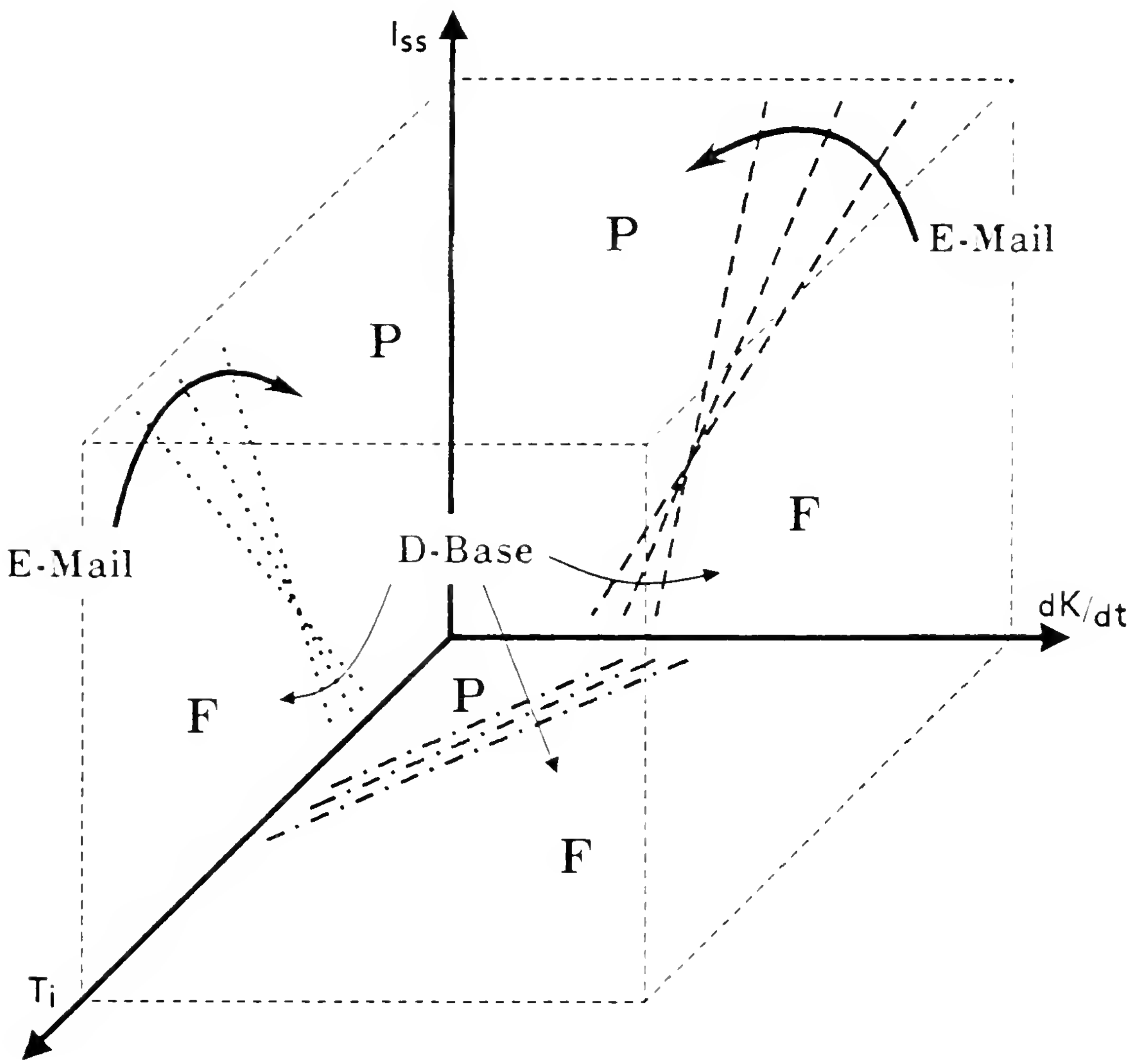
I_{ss} - *Task interdependence*

F - *Functional structure recommended*

P - *Project structure recommended*

E-Mail - *Electronic Mail*

D-Base - *Database for access of scientific and technological literature*



technologies on the Organizational Structure Space will be to move the dividing line between the project and functional regions, changing its slope and position as described in Figures 2 below. In the dK/dt-- T_i plane, because it is difficult to determine which of the two know-how transfer related variables is more amenable to technological treatment, we expect the line to shift slightly from the origin without significant changes of its slope, somewhat increasing the project area. The more usable and powerful is the technology, the larger will be the increase in the set of technical tasks for which the project structure is more effective.

In the dK/dt--I_{ss} plane, there are actually two forces which will operate in opposite directions: first, because the coordinative requirements of the task are assumed to be more amenable to technological treatment, the dividing line will shift towards the dK/dt coordinate, increasing the set of tasks for which the functional structure is recommended. On the other hand, because of the less significant impact of information technologies such as scientific databases on keeping abreast with the technology, the location of the dividing line will shift only slightly from the I_{ss} coordinate, somewhat increasing the set of tasks for which the project structure is recommended. Consequently the more significant shift, increasing the functional area, will occur for tasks of low interdependence and slow advancement of knowledge. On the other hand, the increase in the project area will be smaller and mostly for tasks of rapidly changing technologies and high interdependence. The net change in the set of tasks in the two structure areas will be a function of the power, effectiveness, and usability of the two information technologies -- electronic mail, and scientific and technological databases.

The changes in the I_{ss}--T_i plane will resemble those in the dK/dt--I_{ss} plane, with more significant shift of the dividing line occuring for tasks with lower interdependence and short duration, increasing the functional area, while the less significant increase in the project area will occur for tasks of high interdependence and long duration.

At this stage, because the information technologies mentioned above are only recently being introduced into most of Applied Systems we have little empirical data to support our hypotheses. We expect to complete the ICL Applied Systems study in 1987, and to publish these results. On the other hand, two empirically based topics will be reviewed in the next section of the paper: communication patterns and performance of Applied Systems software development teams, and the PABX SHOWCASE implementation experience. Both have interesting implications for management of technology based organizations, especially those including software development and production, and for vendors and implementors of new information technologies.

PART II: EMPIRICAL DATA FROM ICL APPLIED SYSTEMS

COMMUNICATION PATTERNS AS DETERMINANTS OF SOFTWARE DEVELOPMENT PERFORMANCE

Data and Research Setting

The data on which this section is based were collected at Applied Systems Division, ICL. The communication data was collected (September 1984) via a questionnaire survey of approximately 500 members of the division; 302 (60%) responded to this survey. The software development project performance measures, which were collected (January 1985) from managers of the division, are subjective assessments of performance of 18 project teams on an administrative and a technical dimension. The former included success in meeting designated budget and schedule; the latter, comparative success in product functionality, reliability, and maintainability. In addition to these quantitative measures, the research team conducted as many as 40 interviews with Applied Systems managers about such issues as product and process technology of software development; which are the relevant dimensions of software project performance; and specific software development cases, as described by project managers[1].

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[1] See Hauptman (1986b) Appendix 1.

On the basis of these data the software development tasks were compared with non-software R&D tasks, with special focus on project teams' communication patterns, and the relationship between communication and project performance. Because the findings in this area has recently been published[1], the next section provides only some highlights of these findings.

Optimal Communication Patterns for Application Software Production

The analysis of the relationship between communication patterns and performance of software development projects indicates that the type of tasks involved in software production requires differentiated communication of team members. Designers and analysts, who are responsible for software program architecture, and for the decisions about application software to hardware interface will benefit from technology carrying communication. On the other hand, programmers encoding the program will benefit from reduced coordinative communication. The general presriptions for optimal communication in a nut-shell are: first, the intra-project communication among managers, designers, and programmers should be reduced as much as possible. The negative relatonship between the size of the software development team, and the technical and administrative dimensions of its performance corroborates this finding with statistical significance[2]. Second, frequent communication among the managers and team leaders of a department, which is usually based on a common technology such as graphics, language compilers, or database access tools, contributes to high project performance. Third, communication beyond the department with other members of the business center was found to be inconsequential as far as performance is concerned. Finally, communication beyond the business center, which is usually based in Applied Systems on a specific market application or industry segment, should be minimized and controlled by project managers, or the head of the department.

These findings are very much in line with Brooks's experience[3] with

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[1]Hauptman (1986a).
[2]Hauptman (1986b).
[3]Brooks (1981).

developing the IBM-360 Operating System, which showed that a high cost is to be paid for coordination and mutual retraining of members of large project teams. Nevertheless, these perscriptions are contingent upon several qualifiers, such as the complexity of the software project. They might not apply to all types of software, but mostly to moderately novel applications. For this type of products, though, software "development" is a misnomer. The composits of coding and design should be managed differently, the former as production or manufacturing, while the latter will benefit from informal, face-to-face communication, as a vehicle of keeping abreast with technology and market needs.

In a recent article Hauptman (1986c) recommends a specific floor lay-out for the software development team to enact the optimal communication pattern described above.

Profile of Applied Systems Communication Stars and Gatekeepers

In general the communication patterns of Applied Systems professionals look different from those of non-software tasks. First, the mean intra-project communicaton frequency for the former is less than half of the latter (4.9 versus more than 10[1] contacts a week). This difference is even more pronounced beyond the project team. Finally, the frequency of communication is distributed more unevenly among the members of the software development team; some, mostly managers, monopolize it to greater extent than their opposite numbers in non-software teams. This behavior might reflect the more formal, management controlled communication beyond the project team.

Not incidentally, this monopolization of communication by a few "communication stars" might prove quite effective for software production. In previous studies of non-software R&D projects[1] it was shown that "communication stars" and "gatekeepers", individuals who link their organizational unit with the rest of the organization by

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[1]Allen, Lee, & Tushman (1980) results.
[2]Allen & Cohen (1969); Taylor (1975); Tushman (1977); Allen, Tushman, & Lee (1979); Epton (1981).

communicating frequently externally and internally, have several typicalattributes: they are usually high technical performers on their own; they are of longer than average tenure with the organization; they are not necessarily managers, and if they are, they are usually not higher in the hierarchy than first or second level supervisors; and they are easily identifiable by their peers and managers.

It was quite intriguing to identify the profile of communication stars and gatekeepers in a software development environment such as Applied Systems. Our data (Table I) show that intra-organizational

Table I

Profile of Intra-Organizational Gatekeepers

	GATEKEEPERS (N=30)	THE REST OF THE DIVISION (N=363)
JOB TITLE		
Programmers	16%	55%
Designers	10%	20%
Managers	57%	18%
Marketing Experts	17%	7%
Total	100%	100%
INFORMATION ACQUISITION (average per week)		
Formal Literature	3.0	4.1
Informal Literature	6.0	3.0
Manuals	1.9	2.3
External Contacts	6.6	4.3
Conferences (1982-1984)	1.5	1.3

gatekeepers significantly differ from the rest of the division in their job title, and their behavior in acquisition of information. The difference between the two sub-samples is statistically significant for job titles, where managers and marketing experts are heavily over-represented; in the use of informal literature, such as ICL reports, informal reports from other firms, government and universities; and in the frequency of external contacts, mostly with customers, vendors, consultants, university staff, and colleagues in other firms.

Fifty seven percent of Applied Systems internal gatekeepers were managers. In contrast with non-software projects, where gatekeepers were usually not higher than first or second level supervisors, we found that

Table II

Level of Supervisors Who Are Gatekeepers

LEVEL OF SUPERVISOR	INTRA-PROJECT	PROJECT TO DEPARTMENT	DEPARTMENT TO BUSINESS CENTER	BUSINESS CENTER TO LINE	BUSINESS CENTER TO STAFF
N=	(20)	(8)	(7)	(21)	(19)
FIRST	0%	0%	0%	7%	8%
SECOND	87%	75%	43%	50%	38%
THIRD	13%	25%	57%	43%	53%
TOTAL	100%	100%	100%	100%	100%

software development gatekeepers were usually on the higher rungs of the hierarchy, mostly second and third level supervisors (Table II). In Applied Systems it usually corresponds to project managers and those on the special managerial ladder.

Importance of Communication Related Information Technologies for Software Development

All this implies that coordination carrying communications are very important for organizational perfomance at the software development environment. The costs associated with coordination are quite high. A simplified model[1], which assumes constant coordinating requirements per dyad, and a totally divisible task, exemplifies this issue. The net useful output of the team can be computed as:

$$W(n) = n - kn(n-1) \qquad \text{Eq. 1}$$

when n is the number of team members, and k is the constant proportion of time consumed by the coordination oriented communication effort. The kn(1-n) component is the coordinating cost of the project. On these premises adding another person will result in a net contribution which can be computed by:

$$W(n+1) - W(n) = \underline{1-2kn} \qquad \text{Eq. 2}$$

[1] Howlett (1985).

The "break-even" point of the net contribution, at which it equals zero, is in the realistic range of values when 5% of the time (k=5%) is spent on coordinative communication with each team member of a 10-members team (n=10). On these premises, intra-project coordinative communication looks indeed as a very costly overhead.

But in view of the conceptual model presented in Figure 2 above it seems logical that electronic mail type of information technologies might reduce the coordinative costs of a project. Even a reduction by 40% in the value of the constant k from 5% to 3% will increase the effective maximal size of a group by 60% from 10 to 16, or alternatively, increase the output of the 10-members team by approximately 33%. In addition, if the technology enables a team member to avoid coordination with <u>each</u> of the remaining n-1 members of the team, the coordinating loses will be reduced even more (below the extremum described in Equation 1).

Although these quantitative hypotheses have not been tested yet empirically, on the basis of the more structured nature of software production tasks such as coding, the potential of information technologies for more effective management of these tasks looks quite promising. It seems that in addition to recently introduced programming and design tools such as 4GL (fourth generation languages), code generators, and CAD (computer aided design) for software[1], communication related information technologies might play an important role in the software development environment. The next section describes on the basis of first hand experience with the PABX SHOWCASE team the practical issues of implementating the electronic mail (DRS MAIL, EXAC, ICL MAIL) and voice messaging (VOICE MANAGER) systems at Kings House (REA08) and other locations of Applied Systems Division.

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[1]For details of these technologies see Frank (1983); Friedman (1986).

IMPLEMENTING INFORMATION TECHNOLOGIES IN APPLIED SYSTEMS ICL-
THE PABX-BASED OFFICE SYSTEM SHOWCASE

The Implementation Process

This section attempts to describe from the point of view internal to ICL the chronological events related to implementation of office system information technologies at Applied Systems Division.

The origins of the idea to implement some of the advanced office automation and communication related technologies can be traced to an internal report, which predicted in 1983 considerable potential savings from such technologies for the Applied Systems Division. At the same time, ICL's Office Systems Division (OS) already had a number of products under development, all potentially valuable to the process of automating office procedures.

The traditional reluctance to allow the use of any of these products until they were "perfect" was overcome by two events early in 1984. First came the agreement with MITEL, which allowed ICL to market MITEL's new large digital PABX under the name of DNX2000. The DNX2000 has both data and voice-switching capabilities and is a non-blocking switch, in other words the data being put through do not affect the capacity for voice traffic. The second initiative was the determination of the then chief executive Rob Willmont and his senior team, including Michael Scott Morton from MIT, that the PABX and the OS products should be tried out in a realistic environment. A major proviso was that the lessons relating to product, user attitudes, management, organisation and marketing should be properly documented and reported on, and where appropriate incorporated in future versions of the product.

The twin concept of learning from internal application of ICL products while improving productivity in the host division was given the title of "Showcase". The term was primarily intended to convey that ICL should show how it used its own technology and what benefits could be obtained. Although "Showcase" rapidly became confused with "Showplace" only coincidentally was any aspect of a demonstration site included in the original concept.

The Showcase established in Applied Systems was to explore first the use of the PABX itself as a switching medium for data traffic, instead of the usual mainframe or LAN technologies. A few other suppliers of PABXs actively promoted the PABX as a switching medium for data but there were few signs of significant implementation. The second objective of the PABX Showcase was to explore the use of ICL's office products in a working environmnet. To do this the Showcase sought to combine the Company's products in messaging, mail, and storage and transfer ot text, data and image into an integrated system serving the needs of Data Processing (DP) professionals, administrative staff, secretaries, and managers. As conceived early in 1984, these functions would have been provided at every desk where they could be justified, using whatever technology might be appropriate. The project was to be carried out by the Group Information Systems (GIS), the Group responsible for ICL's own internal systems.

Incidentally, the implementation of the Showcase offered an attractive research opportunity for the Management in the 1990's Research Programme of MIT. The close relationship between the sponsoring organisation, in this case ICL, and the research team promised a longitudinal, detailed, and rigorous project from initiation to completion. The target population of the Showcase - software development professional and managers at Applied Systems - was of significant size, and held important practical issues, e.g., management, communication, and performance of software development teams. The technologies to be implemented, and the mode of implementation offered a very valid research design, with the potential to directly measure the changes generated by the technologies, and their diffusion in the target population. The diversity of sites across the country, products and markets, and software technologies contributed to the strength of the research design. One of the most important factors was the fact that the divisional director was eager to realise the advantages to be gained not only from IT but also from overlaying the rigour of an academic research project on the practicalities of an internal project.

But the Management in the 1990's project had hardly got under way when certain changes were required to the Showcase structure which

were to have far reaching effects. By October/November 1985 lessons were already beginning emerge about the Showcase concept itself. Three major roles had been clearly recognised, namely the project owner, the host, and the watcher, whose terms of references could be summarised as follows:

1. The owner is the part of the organisation which could expect to derive the longer-term marketing benefits from the project;
2. The host could be expected to derive any short-term productivity gains;
3. The watcher is to document the lessons and ensure that they are properly reported on.

But the implementation could not survive in this simple structure, without several additional actors, i.e., "sub-contractors". These included:

1. Office Systems Division for products such as electronic mail and text processing services;
2. Network Services Division for internal networks services plus connections to external services such as the public telephone network, telex, and facsimile facilities;
3. Mainframe Systems Division since some of the facilities to be accessed by the PABX Showcase were mounted on ICL corporate mainframes;
4. Group Information Systems (GIS) who operated Group Databases and maintained all equipment at ICL.

The involvement of these actors could be expected to fluctuate from time to time as the Showcase team sought to implement or demonstrate various features.

Against thess definitions Applied Systems Division remained the host. But the main long-term beneficiary from testing the PABX-based Office System was undoubtedly the DNX Division, who took over formal ownership of the Showcase from GIS, and was to be responsible for marketing of the PABX itself. The logic of this transfer of ownership is beyond the scope of this paper. However, it was decided that the objectives of the DNX Division could be achieved by a relatively modest pilot exercise, and consequently the initial implementation plan for

having the Office Systems functions at every desk was dramatically altered. Thus Applied Systems became responsible for funding its own implementation programme.

One of the side-effects of these changes was on the Management in the 1990's study. Obviously, the diffusion of the technologies was slowed down considerably. Neither the DNX nor the AS Division had been funded for bulk diffusion of IT and under the modified Showcase structure the Showcase team had to isolate quite specific areas which could be tackled and in particular to build on whatever existing technology was in place.

Initial assessment

The initial quantitative data (Table III) show the compartively low rate of use of the voice messaging (circa May 1985) among survey

Table III

Data on Use of the Voice Messaging System (VOICE MANAGER)

Frequency of access:	
- less than 3 times a day	59%[1]
- 3-5 time a day	35%
- 6-10 times a day	4%
- More than 10 time a day	2%
Diversion of calls to the Voice Manager:	
- less than 3 times a day	98%
- more than times a day	2%
Number of messages received via Voice Manager:	
- less than 3 messages a day	85%
- 3-5 messages a day	13%
- More than 5 messages a day	2%

Notes: [1]59% response rate out of 96 to whom the Showcase internal survey was sent.

participants. The results of a Management in the 1990's survey in early 1986 about the use of the Voice Manager, and the electronic mail facilities (DRS Mail, EXAC) are not very different (Table IV). The utilisation rate probably still suffered from lack of critical mass of users.

Table IV

Use of Information Technologies in January-February 1986

Owners of information technologies[1] among survey participants:	Number	Proportion[2]
- VOICE MANAGER	47	25%
- EXAC	31	16%
- DRS MAIL	13	7%
Usage during last week:	**Number**	**Proportion[3]**
- VOICE MANAGER	4	9%
- EXAC	19	66%
- DRS MAIL	4	31%
Number of people accessed through:	**Number**	**Per user**
- VOICE MANAGER	4	1.00
- EXAC	62	3.26
- DRS MAIL	21	5.25

Notes: [1]42.4% response rate out of 448 survey population; [2]Proporation of owners among respondents; [3]Proporation of owners of the system who used it at least once a week.

In addition, most of the special features of the Voice Manager were used only by a minority of the owners of the system. For instance, 26% used the "Timed Delivery" and the "Priority Messaging" options, 35% used "Disrtibution Lists" and "Confirmed Delivery", 18% - "Redirect Message", 22% - "Immediate Reply", and 44% - "Personal Response". On the other hand, some of the reactions were quite positive even for the initial stage of implementation, indicating a somewhat bi-modal dsitribution of attitudes towards the new technologies (Table V below). In other words,

Table V

Highlights of Voice Manager Assessment by Users

BENEFITS	PROPORTION WHO INDICATED POSITIVE INFLUENCE[1]
-Time saving	72%
-Increased contact	65%
FEATURES	**PROPORTION WHO FOUND FEATURE VERY USEFUL**
-Confirmed delivery	13%
-Personal response	10%
-Distribution lists	26%

Notes: [1]59% response rate out of 96 to whom the Showcase internal survey was sent.

while the majority of the owners of the system, for various reasons, have been using it very sparcely, a significant proportion of this population found it useful and satisfactory for their needs.

On the technical side the Showcase demonstrated the feasibility of using the PABX to connect a variety of users to a number of functions, using various types of terminals (see Figure 3 and Appendix C for details). In addition, access to other functions was explored and the capability of connecting portables, home computers, and "foreign" equipment was also demonstrated.

The routing and queuing software available with the PABX enabled substantial cost reductions to be made for casual users. For instance, it was possible to connect a large number of users to the 4-port PC, the actual number being limited only by the frequency of access of the users concerned. Also the simplicity of connection provided a rapid means of dissemination to satisfy emergency requirements, pending a more permanent connection. In addition, the Voice Messaging Service was accessed through the PABX without a software connection between the two.

Experiences

Although the "hard" quantitative data about the implementation of the office systems technologies is still lacking, the opportunity to observe the implementation in action provided us with some anecdotal information about the process. The highlights of these data are provided below.

Simple improvements in speed, convenience and confidence:

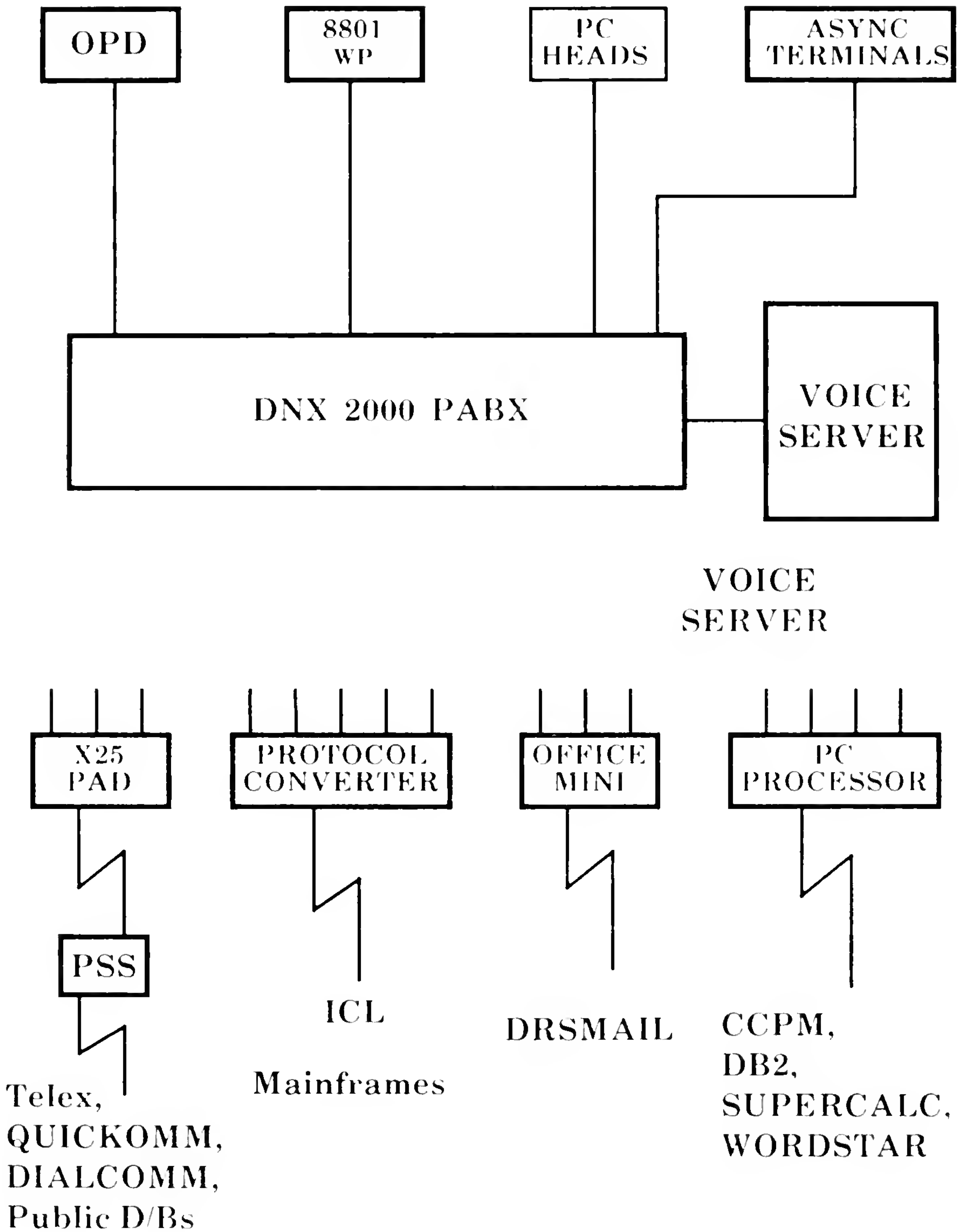
-A secretary could now send an urgent telex directly from the Word Processor, rather than having to type it out and take it personally to the Telex Room, and be confident that it had gone;

-The Voice Manager enabled Personnel Department and sales teams, which both are dispersed physically - to distribute messages and arrange meetings much more easily than before.

The need to consider change of roles and to rethink methods of working:

-Telexes could be sent at any hour of day or night, initially from any 8801 Word Processor connected to the PABX and later from any

Figure 3: PABX SHOWCASE



terminal. The Voice Manager could be similarly accessed and was available from any location worldwide with a tone-generating telephone. A substantial potential for independence was therefore created;

-Salesmen found they were no longer tied to times and places from which to communicate with head office, while the Sales administrator was able to send individual or communal messages knowing that those concerned would pick them up when convenient, without worrying about their location;

-The Personnel Manager enterprisingly used the Voice Manager for remote dictation of minutes into his secretary's voice mail box, thus speeding up distribution by two to three days;

-The power of integrated facilities was demonstrated when a substantial questionnaire received on DRS MAIL was downloaded to the 8801 Word Processor, completed by using the editing facilities, reloaded to DRS MAIL and returned to the originator within 20 minutes without any paper being produced;

-A maintenance engineer treated his voice mail box exactly like his document in-tray - checking it at periodic intervals and prioritising the contents before continuing with his peripatetic tasks.

Unsuspected gaps in knowledge were uncovered:

-Many secretaries were unaware of the answerback convention and its use. The Central Telex Operator had previously checked answerback codes for correctness of destination.

-Access to machine-held directories was not commonly a familiar feature.

Increased use of a facility, carried by another facility, threatened to swamp the carriers - even a modest increase in direct access to external electronic mail services caused congestion on the ICL X25 PAD.

Dual use of the telepnone was not always productive - those secretaries not at Divisional headquarters were not able to release the telephone once they had accessed the facility required (further DNX2000's had not then been installed). When compounded with congestion on the X25 PAD this gave rise to a conflict - either the secretary kept her phone

tied up or she risked losing the chance of gaining access.

Further, a system which guides a user through several layers of technology to the facility one wants must provide a similarly all-embracing support service against failure in any one of the layers. The user will rarely be able to identify whether the fault is in the terminal hardware or software, the modem, the PABX, the ICL network, or the facility itself. Incidentally, the most common fault was saturation of the carrier services, as described above.

On the product side it was obvious that some routines had been written by programmers for programmers. DRS MAIL for instance, is extremely easy to use as long as one sticks to the basic functions. However, to set up a distribution list requires knowledge of the system's file structures and naming conventions - plainly a knowledge few users could be expected to muster.

Work-flow was changed with not everyone an unqualified beneficiary. For instance, in the past the majority of telexes were not sent by secretaries, and as knowledge of the facility spread rapidly, the danger arose that secretaries' workload would rapidly increase. Also the penchant for keeping a hard-copy of everything initially caused a flood of extra copies addressed to the sender and needing to be sent from central telex switch instead of being printed automatically at the local telex-room.

SUMMARY: LEARNING FROM EXPERIENCE AND RESEARCH

Research and the PABX Showcase

The experience of implementing information technologies at ICL contributes to the growing knowledge base in this area, both academic and industrial. For instance, several recent papers address electronic mail implementation in business organizations, and are highly relevant for comparison. First, Picot, Klingenberg, and Kranzle (1982) detailed field study of how the various communication media, from face-to-face, through telephone, telex, mail and facsimile, to teletex (an electronic mail

protocol), are perceived by managers. It comes as no surprize that face-to-face and telephone are perceived as superior to the indirect, asynchronous channels for stimulation and privacy (with the exception of mail, which rated quite well for privacy). On the other hand, the teletex is highest on dependability and rates better than face-to-face for comfort and formality (see Appendices B1-B3 for details). On the task-oriented dimensions teletex is percieved superior than face-to-face on promptness and accuracy, but is definitely worse on complexity and confidence. The authors also provide data about the potential restructuring of channel utilization; teletex seems to be not a very strong competitor to face-to-face communication (only 5% of this type of communication is percieved to be potentially replaced by it). Mail and telephone rate only somewhat better with 12% and 18% potential replacement by teletex. Because of the use perceptual, subjective data, this study still leaves open the issue of actual restructuring of communication when computer-based media are introduced. The completion of the communication study at Applied Systems should provide us with one of the first results in a reliable, quasi-experimental setting in this field, in a real-life situation.

There are several studies which come close to address the central issues of use, implementation, and benefits that could be expected from information technologies. Steinfield's study (1984) is an effort to clarify the typology of communication tasks that could be performed effectively via electronic mail. He found a clear distinction between social and task usages, and to what extent each sub-task was susceptible to mediation by electronic mail. His results support Picot et al. warning about over estimating the impact of information-communication technologies on complex tasks. He found that such tasks as "carry on negotiations/bargaining", "resolve conflicts/disagreements", "discuss confidential matters", had <u>never</u> been carried out via the computer by at least 50% of the respondents. Using Watzlawick, Beavin, and Jackson (1967) definitions, "analogue" communication might continue to elude the computer-based media.

Culnan (1985) addressed the narrow issue of perceived accessibility of the medium as a determinant of its use. Her results suggest that

physical access to a system is only a necessary, but also an insufficient condition. Controlling for the other variables, system usage correlated significantly only with knowledge of the command language, and information accessibility, but not with terminal accessibility, or overall reliability of the system. Her results validate and update what Allen found about the importance of accessibility as determinant of source utilization (1977: 185).

The general reliability of a complex system, in reality a range of interlocking subsystems, and the "splash and ripple" effects of adding new components or subsytems has been approached by a number of writers (see for instance Jenkins, 1969) but could well be a fruitful field for more determined and systematic research.

Practical Lessons for Managers

The Managment in the 1990's project and the PABX Showcase each carry important lessons and pointers for future research, development and implementation of communication technologies, and for organisational requirements to achieve results from investment in information technologies.

The correlations between communication and performance, differing according to the boundary-penetration of the communication and the variation in its intensity among individuals, and the type of task performed suggest an opportunity to broaden our approaches to management of projects and office lay-outs. There may well also be scope for more extensive research into communication profiles and their relationship to the effectiveness of entire departments and sections.

The conceptual model of organizational design, based on task duration, rate of technological progress, and sub-task interdependence, and the influence of information technologies on this design is an example of potential know-how transfer from academia to industry. Its value as a consulting tool in the arsenal of a vendor of office automation and related technologies, as well as an internal managerial guideline can be tested in practice, the former, by ICL external consultants with their customers, the latter, by ICL's internal managers.

These are only some of the potential future possibilities. Additional, more far reaching usages of this knowledge remain tantalisingly blurred. Is it possible to build a portfolio of communication patterns, each relevant to a particular type of activity in a particular industry? If so, there would a powerful diagnostic tool for measuring organisational communication. In addition, detected deviations from the communication structure recommended for this type of task and industry will provide indirect measures of organisational effectiveness.

The final stage of the Management in 1990's communication at Applied Systems will attempt to address these issues, and to provide some of the answers.

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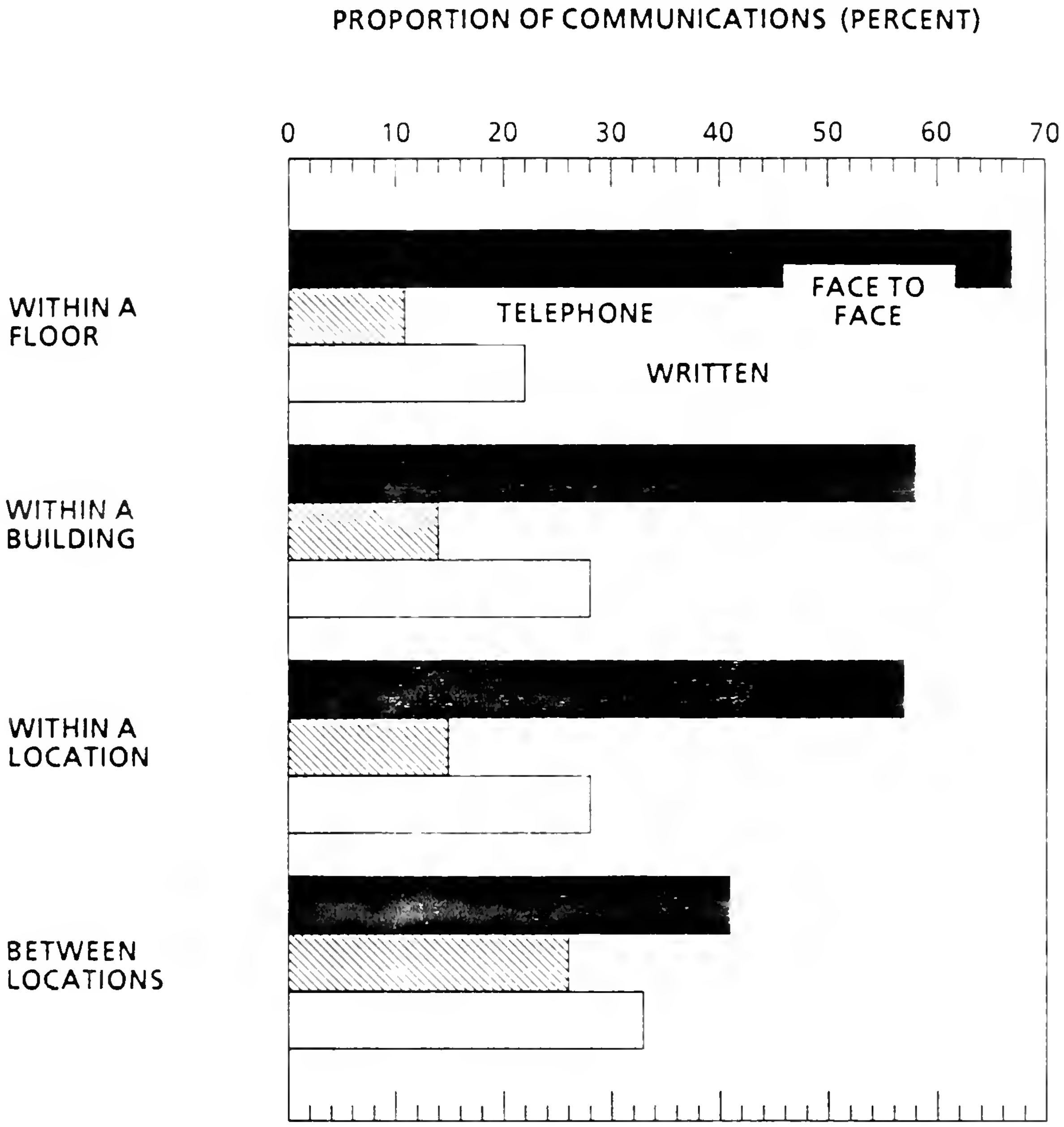
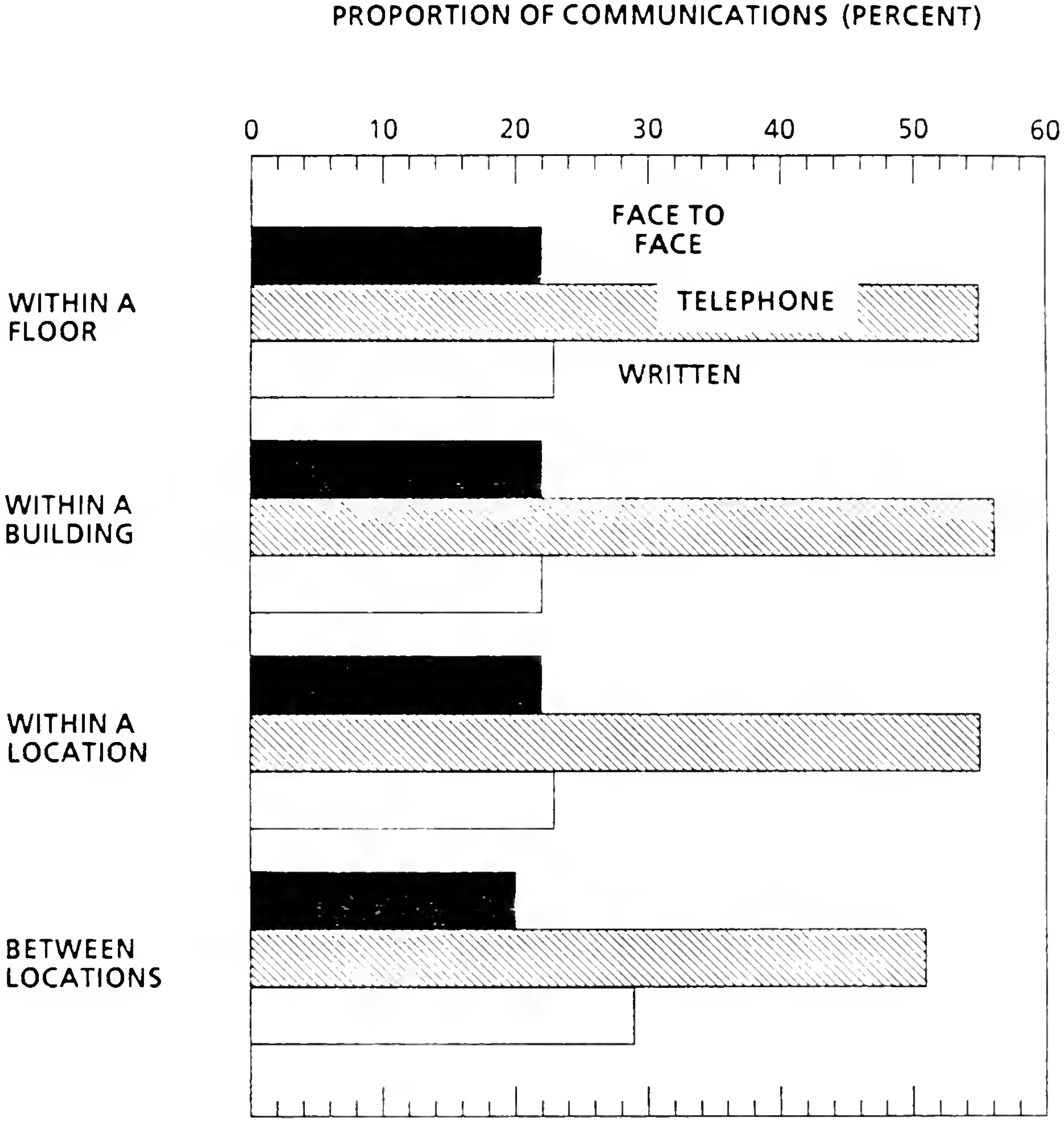
APPENDIX A1:

COMMUNICATION MEDIUM AS A FUNCTION OF PHYSICAL SEPARATION (HIGH COMPLEXITY INFORMATION)



APPENDIX A2: **COMMUNICATION MEDIUM AS A FUNCTION OF PHYSICAL SEPARATION (LOW COMPLEXITY INFORMATION)**



Appendix B1:
Affective Evaluation of Communication Channels

	Channel					
Factor	Telephone	Face to Face	Mail	Telex	Fax	Teletex
Stimulation	2.6	2.3	3.1	3.3	3.5	3.1
Comfort	1.4	2.4	3.3	2.4	2.1	2.3
Dependability	2.5	2.1	1.9	2.0	1.9	1.9
Formality	4.0	4.1	2.9	3.1	3.2	3.2
Privacy	2.3	1.5	2.0	3.8	3.9	3.3

1 = appropriate; 5 = totally inappropriate

Picot, Klingenberg & Kränzle (1984)

APPENDIX B2:

TASK-ORIENTED EVALUATION OF COMMUNICATION CHANNELS

	CHANNEL					
FACTOR	TELEPHONE	FACE TO FACE	MAIL	TELEX	FAX	TELETEX
PROMPTNESS	1.4	3.8	4.0	2.5	2.4	2.6
COMPLEXITY	2.3	1.4	3.1	3.5	3.1	3.1
CONFIDENCE	3.1	1.7	1.9	3.5	3.1	3.2
ACCURACY	4.4	3.9	1.8	2.5	2.1	1.8

1 - VERY GOOD; 6 = VERY BAD

PICOT, KLINGENBERG & KRÄNZLE (1984)

APPENDIX B3:

SUBJECTIVE ASSESSMENT OF POTENTIAL CHANNEL SUBSTITUTION (N=96 MANAGERS)

REPLACED CHANNEL	REPLACING CHANNEL					
	PHONE	FACE-TO FACE	MAIL	TELEX	FAX	TELETEX
FACE-TO-FACE	28%	---	13%	2%	2%	5%
PHONE	---	20%	16%	9%	5%	12%
MAIL	15%	13%	---	7%	10%	18%

SOURCE: PICOT, KLINGENBERG & KRÄNZLE (1984)

Appendix C: Details of Showcase Technical Parameters

The principle functions accessed:

- External Electronic Mail - Telex, Quickcomm, MCI Mail,
- Internal Electronic Mail - ICLMAIL, DRSMAIL, EXAC,
- Local Computing - PCs, running CCPM,
- Mainframes - Large Data Bases,
- Public Data Bases and Services.

The following terminals were in regular use to access the functions:

- OPD (One Per Desk, ICL),
- DRS (ICL),
- STC,
- PC Heads (the direct connection to the processor was diverted via the DNX2000),
- 8801 Word Processor (ICL).

Date Due

MAR 4 1990		
OCT 23 1991		
MAR 0 3 1992		
1994		